STANDARD SAMPLES OF PHOSPHORS

Technology

THE National Bureau of Standards has recently made available 14 standard samples of phosphors selected in cooperation with the Electrochemical Society. The samples were prepared under the supervision of Dr. A. F. Forziati [1] in the dental research laboratory and may be obtained from the Supply Division, National Bureau of Standards, Washington 25, D. C. The phosphor samples are for industrial and research use in quality control and development of improved phosphors for radar screens, television sets, and radioactivity counters and detectors. The main concern in preparing the samples was to achieve uniformity of characteristics and thus to provide a fixed basis for comparison with other phosphors.

Phosphors are luminescent materials with many applications. For example, they are employed in the manufacture of luminous paint for watch and instrument dials, advertising displays, and theatrical effects; fluoroscopic screens for X-ray investigations of opaque articles and for visual presentation of images in the electron microscope; high-speed X-ray film; image converters for changing invisible radiation into visible light as in the so-called "snooperscope"; and fluores-

cent lamps emitting in the ultraviolet or visible regions of the spectrum.

As might be expected, phosphors employed in such a variety of applications must have different properties. An important example is the wide range of requirements in regard to decay time or length of persistence of luminescence. Thus, in the case of a television tube, the luminescence must not persist longer than one-thirtieth of a second; otherwise, the picture appears to drag across the screen, followed by a slowly disappearing ghost image. In contrast, if a satisfactory image is to be maintained on a radar screen, the duration of the phosphor's luminescence must be consistent with the scanning antenna's period of rotation. At the other extreme is the phosphor used in a radioactivity counter; here the decay time often must not exceed 10^{-8} sec so that each particle emitted by the radioactive source may register separately on the counter.

In color television applications, not only the purely physical properties (excitation wavelength, emitted wavelengths, decay time) but also color, a psychological factor, must be considered. Hence, in some instances, the tristimulus coordinates of chromaticity of

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NEW STANDARDS

The first three articles of this issue announce the availability of 16 new standard samples and 7 new reference standards. These standards are part of a program in which the Bureau provides approximately 600 standard samples and reference standards to industrial and research laboratories. The materials are certified either for chemical composition or for some physical or chemical property.

A step in the preparation of phosphor standard samples.
An atmosphere of dry nitrogen is maintained in this
glass-covered enclosure to prevent decomposition of the
phosphors while they are being weighed and bottled.

Fourteen standard samples of phosphors are now available from the Bureau. These five phosphor specimens fluoresce in different colors when excited by the ultraviolet lamp (left) emitting 2537-A radiation. The samples are shipped in containers like the one shown at right.

phosphors are specified. Even the ordinary fluorescent lamp poses a color problem. It is aesthetically unpleasant to view an array of lamp fixtures when the colors match poorly.

The 14 standard samples of phosphors that have thus far been prepared are listed in the table, together with their symbolic formulas, weights, and prices. The spectral emission of these phosphors varies from the ultra-violet through the blue and red regions of the spectrum when excited by ultraviolet radiation (2537 or 3650 A) or by cathode rays.

As the physical properties of these samples have not yet been measured, it is intended that they serve only as common reference materials for comparison of research phosphors. However, for the most part they represent the optimum efficiency of phosphors currently produced. An investigation of their basic physical properties is planned. Information thus obtained will simplify commercial production of phosphors that conform to specifications, and may also lead to new, improved standards.

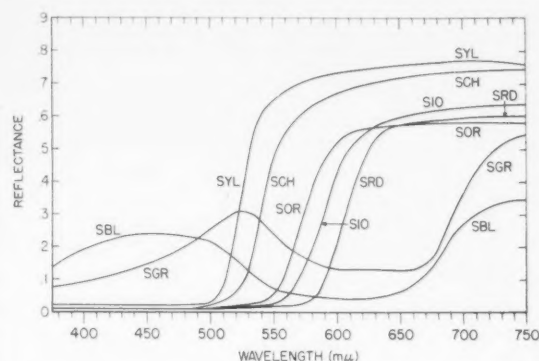[1] *Dr. Forziati is a research associate of the American Dental Association.*

Phosphor standard samples

Sample No.	Name	Symbolic formula	Remarks	Approximate weight	Price per sample
				g	
1020	Zinc sulfide phosphor	$ZnS:Ag$	Blue component of P-4 phosphor	14	$3.00
1021	Zinc silicate phosphor	$Zn_2SiO_4:Mn$	P-1 phosphor as used in cathode-ray tubes.	28	3.00
1022	Zinc sulfide phosphor	$ZnS:Cu$	P-2 phosphor	14	3.00
1023	Zinc-cadmium sulfide phosphor	$ZnCdS:Ag$	Yellow component of P-4 phosphor.	14	3.00
1024	Zinc-cadmium sulfide phosphor	$ZnCdS:Ag$	Orange component of P-14 phosphor	14	3.00
1025	Zinc phosphate phosphor	$Zn_3(PO_4)_2:Mn$	Red component of P-22 phosphor.	28	3.00
1026	Calcium tungstate phosphor	$CaWO_4:Pb$		28	3.00
1027	Magnesium tungstate phosphor	$MgWO_4$		28	3.00
1028	Zinc silicate phosphor	$Zn_2SiO_4:Mn$	As used in fluorescent lamps	28	3.00
1029	Calcium silicate phosphor	$CaSiO_3:Pb,Mn$		14	3.00
1030	Magnesium arsenate phosphor	$(MgO)_x(As_2O_3)_y:Mn$		28	3.00
1031	Calcium halophosphate phosphor	$3Ca_3(PO_4)_2 \cdot Ca(F,Cl):Sb,Mn$		28	3.00
1032	Barium silicate phosphor	$BaSi_2O_5:Pb$	Near ultraviolet emission	28	3.00
1033	Calcium phosphate phosphor	$Ca_3(PO_4)_2:Tl$	Erythemal ultraviolet emission	28	3.00

A complete list of standard samples and reference materials issued by the Bureau is contained in NBS Circular 552, Standard Samples—A Catalog of Reference Materials Issued by the National Bureau of Standards, price 25 cents, available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C

Safety Color Standards

A SERIES of chromatic reflectance standards for seven safety colors is now available from the Bureau. These standards are provided to calibrate photoelectric tristimulus colorimeters, which are being increasingly used to control color and to measure color and color differences. Each of the standards represents a commercially important region in color space that is used to indicate safety hazards. The present series supplements the ten color standards for kitchen and bathroom accessories that have been issued by the Bureau during the past 8 yr for tristimulus colorimetry.[1]

Color name	Code designation	45°0° CIE tristimulus values for source C *		
		X	Y	Z
Safety red	SRD	0.17	0.09	0.01₂
International orange	SIO	.26	.15	.01₃
Safety orange	SOR	.32	.21	.01₄
School bus chrome yellow	SCH	.49	.42	.01₅
Safety yellow	SYL	.56	.55	.03₁
Safety green	SGR	.15	.21	.18
Safety blue	SBL	.09	.09	.27

* Source C—average daylight illumination.

Spectral characteristics of the seven safety color standards: Safety blue (SBL), safety green (SGR), safety yellow (SYL), school bus chrome yellow (SCH), safety orange (SOR), international orange (SIO), and safety red (SRD).

The new standards are 4¼-in.-square, porcelain-enameled iron plaques. The colors of these standards have been given the names of safety red, international orange, safety orange, school bus chrome yellow, safety yellow, safety green, and safety blue. The table lists their code designations and CIE (International Commission on Illumination) tristimulus values X, Y, and Z, for average daylight illumination.

The plaques are intended primarily to serve as reference standards for the photoelectric colorimeters that are extensively used to measure 45°0° directional reflectance (45° average daylight illumination, perpendicular viewing) of opaque specimens. These laboratory instruments are equipped with photocells, light source, and tristimulus filters with spectral specifications approximating those of the CIE standard observer and coordinate system.

The effectiveness of a photoelectric colorimeter is limited by (1) nonlinearity of its photometric scale, and (2) failure of the source-filter-photocell combi-

nation to duplicate exactly the spectral character of the three CIE tristimulus functions. Accuracy of the photometric scale can be ascertained by use of a series of nonselective standards ranging from white through gray to black. However, when the source-filter-photocell combinations do not conform to the CIE tristimulus functions, it is necessary to calibrate the colorimeter with chromatic reflectance standards. These standards are most useful for the tristimulus colorimetry of test specimens of nearly the same spectral character as that of the standards.

Although the safety color standards have been selected for their superior surface uniformity, a certain amount of nonuniformity is unavoidable. In order to minimize nonuniformity effects, the plaques should be positioned in the colorimeter so that the center of the illuminated area coincides with the center of the plaque. Uncertainties in reported tristimulus values for the plaques vary approximately from ±0.004 for high reflectances to ±0.002 for low reflectances. The true tristimulus value is expected to lie outside the indicated range in only one instance in a thousand.

The price of a complete set of the safety color standards is $83.00. Individual standards may be obtained from the Photometry and Colorimetry Section, National Bureau of Standards, Washington 25, D. C. for $28.00 for the first plaque, and $10.00 for each additional plaque.

[1] Chromatic reflectance standards, *NBS Tech. News Bul.* **34**, 110 (1959).

Photoelectric tristimulus colorimeter used to measure the directional reflectance of safety color standards (plaques at left).

Standard Samples for Rubber Compounding

THE BUREAU has added two new standard samples to its list of materials for rubber compounding. They are Standard Samples No. 383, mercaptobenzothiazole, and No. 385, natural rubber. A total of 17 reference standards, including vulcanizing agents, accelerators, fillers, and other compounding ingredients, are now available for use in the quality control of rubber raw materials and rubber production.

The new standards represent the culmination of work started at the Bureau in 1927. At that time a program was sponsored by the Division of Rubber Chemistry of the American Chemical Society, and the Rubber Manufacturers Association to develop methods for evaluating plantation rubber. The standard formula and procedures used today for preparing test vulcanizates of natural rubber resulted from that early effort.

When studies to improve natural rubber testing were resumed at the Bureau in 1948, it was recognized that a standard sample was needed as a yardstick for standardization of testing in rubber laboratories throughout the world. Standard Sample No. 385 fills this requirement. With the establishment of Standard Sample No. 383, the list of compounding ingredients needed to test natural rubber is complete.

These two new materials also complete the standard samples required for preparing the standard natural rubber compounds of the American Society for Testing Materials.[1] The 17 standard samples with their prices and weights are listed in the table. They are available from the Supply Division, National Bureau of Standards, Washington 25, D. C.

[1] See ASTM Designation D15–57T.

NBS Standard Samples for rubber compounding

| Number	Name	Approximate weight of sample	Price per sample
		g	
370	Zinc oxide	2,000	$2.15
371	Sulfur	1,400	1.75
372	Stearic acid	800	1.90
373	Benzothiazyl disulfide	500	1.75
374	Tetramethylthiuram disulfide	500	3.50
375	Channel black	7,500	3.50
376	Light magnesia	450	2.40
377	Phenyl beta-naphthylamine	600	4.00
378	Oil furnace black	7,000	3.50
379	Conducting black	5,500	3.50
380	Calcium carbonate	6,000	2.50
381	Calcium silicate	4,000	2.50
382	Gas furnace black	7,500	3.50
383	Mercaptobenzothiazole	800	2.75
385	Natural rubber	31,500	44.00
386	Styrene-butadiene rubber, type 1500	34,000	38.00
387	Styrene-butadiene rubber, type 1000	34,000	(a)

a To be revised.

Improved Map Paper

A MAP PAPER of high-dimensional stability, particularly suitable for special military maps and charts, has been developed by the Bureau for the Army Engineer Research and Development Laboratories. The work was carried out by Gerald L. McLeod and Thelma L. Worksman of the paper laboratory, as part of a broad program of research on the properties of paper and related materials. It is expected that the use of the paper will be limited to military maps and charts requiring the highest degree of accuracy.[1]

Paper on which multicolored maps are printed should have good dimensional stability, or more specifically, low-moisture expansivity. Otherwise, changes in the paper's moisture content can cause misregister of successive impressions during the printing process. In addition, nonuniform changes in the dimensions of the paper result in inaccurate distance readings in the finished map.

The fibers of machine-made paper tend to fall lengthwise on a moving wire mesh as the paper is formed. This direction of strain is called the "machine direction". When the wet paper is pulled from the wire mesh through dryers, it is strained both in the machine direction by the pull, and in a right-angle direction— referred to as the "cross direction"—by the machine's restraint on its shrinkage.

Moisture expansivity is usually less in the machine direction than in the cross direction. Although a paper with little or no expansivity would be most desirable for multicolored map printing, a paper with reduced, but uniform expansion in both directions would be an
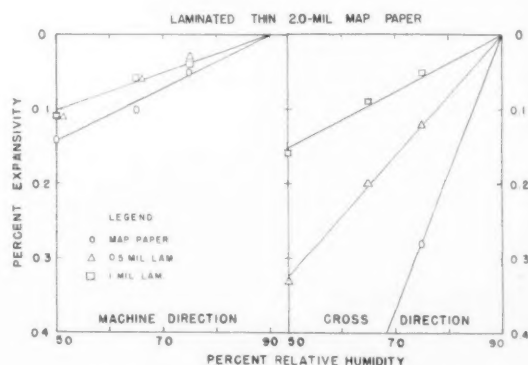
Percentage expansivity of regular map paper and two laminated papers between 90- and 50-percent relative humidities. Ninety-percent relative humidity was taken as the "zero" or starting point.

Mechanical strength of regular high wet-strength map paper and of laminates made with thin map paper and polyethylene terephthalate film

Tests	4.2-mil regular map paper [a]		Thin map paper laminates	
	Federal specification requirements [b]	Observed values	1-mil film	0.5-mil film
Basis weight, 17×22—500 .... lb.	24 ±5%	23.7	29.1	25.8
Thickness .... in.	0.0042 ±0.0005	0.0041	0.0048	0.0045
Expansivity per 15% relative humidity change between 65—50% maximum:				
Machine direction .... %	0.075	.07	.05	.05
Cross direction .... %	.25	.21	.07	.12
Folding endurance, Schopper; double folds:				
Machine direction	1,000	1,408	>10,000	>20,000
Cross direction	1,000	1,300	>10,000	>10,000
Bursting strength:				
Dry .... point	50	50	62	52
Wet with water .... do	20	30	45	38
Tensile strength, dry:				
Machine direction kg/15mm	11	11.8	14.9	12.2
Cross direction .... do	6	6.8	8.7	6.6
Tensile strength, wet:				
Machine direction .... do	3.5	4.4	7.7	3.8
Cross direction .... do	2.5	2.8	5.6	3.0
Tearing resistance:				
Machine direction .... gram	95	85	132	106
Cross direction .... do	95	94	140	94

[a] Commercial sample.   [b] All figures are minimum values unless otherwise designated.

improvement. To develop such a paper without losing other essential properties such as tearing resistance and folding endurance, the investigators tried laminating two thin sheets of paper to a backing of plastic film. making a "sandwich" with the film as the middle layer. Polyethylene terephthalate was selected as the backing because of its strength and dimensional stability.

Since this film is unstable at the high temperatures normally required for carrying out the lamination process. an adhesive was used. As the adhesive was a water emulsion, it was applied to both sides of the film, instead of directly to the paper; cockling was thus avoided. After the adhesive dried, one sheet of paper was bonded to each side of the film by maintaining the components at 115° C for 1 min on a steamheated. water-cooled flatbed press under a pressure of 200 lb/in². A special 2-mil map paper (about half the thickness of regular map paper) prepared in the Bureau's experimental paper mill was used. together with film of two different thicknesses. 0.5 and 1 mil.

Moisture expansion measurements were made with an apparatus[2] in which changes of length of paper specimens are produced by controlled variations of the relative humidity. The resulting expansion was calculated by means of an optical lever. a device that amplifies and measures small displacements. Expansivity of the specimens was calculated for the relative humidity changes between 90 and 75. 90 and 65, 90 and 50. and 65 and 50 percent.

In the 15-percent change between 65- and 50-percent humidity (the conditions required by the Federal specification for map paper) the "cross direction" expansivity measured was 70 percent less in the 1-mil film and thin-paper specimen than in regular map paper. A reduction of about 30 percent was obtained in the "machine direction". resulting in the formation of a nearly "square" sheet; that is. one in which the expansion is almost the same in both directions (see table). Tests of folding endurance. bursting and tensile strengths, and tearing resistance indicated that the laminated paper has better physical properties than the regular map paper used for the multicolored printing of military maps.

[1] See Improved dimensional stability in laminated paper. by Gerald L. McLeod and Thelma L. Worksman. TAPPI (in press).
[2] For a detailed description of the apparatus see TAPPI Standard T 447 m–53.

Miniature Fourdrinier paper-making machine used for experimental purposes. The very thin paper stock employed in the laminating process was produced by this machine.
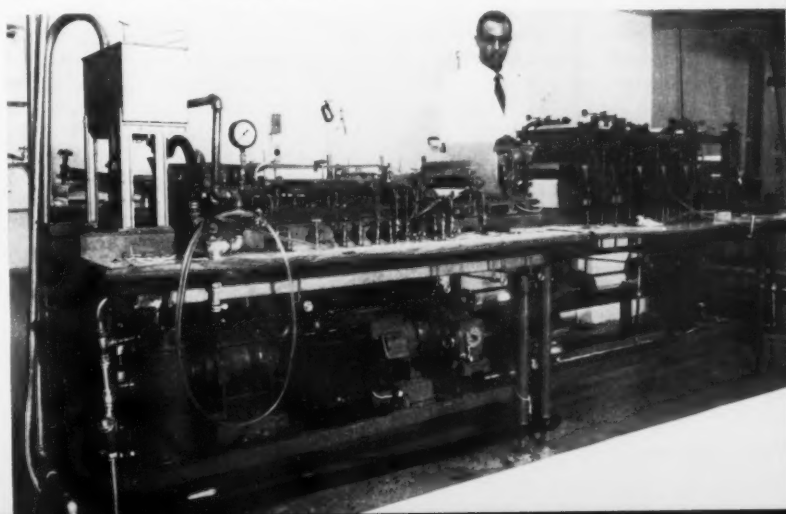
Isotopic Tracer Study of Cool-Flame Oxidation

Separation of Cool-Flame Combustion Products

BUREAU research on the chemical properties of fuels, sponsored in part by the Air Force Office of Scientific Research, has resulted in successful separation of the products of "cool-flame" oxidation of propane.[1] Devised by R. E. Ferguson and C. R. Yokley of the Bureau staff, the method of separation employs a combined gas-liquid, gas-solid chromatographic technique that is specifically adapted for isolating oxidation products of propane–2–C^{13}. This tracer compound, containing the C^{13} isotope in the middle position, is used to follow the course of the reaction and reaction products.

Cool-flame oxidation is an important part of the autoignition reactions associated with engine "knock". Study of the separated oxidation products is thus expected to provide fundamental data on the mechanism of autoignition in hydrocarbon-air mixtures. This work is part of a larger Bureau effort designed to close the existing gap between basic research in combustion and advanced engine applications.

Cool-Flame Reactions

Knock is caused by the spontaneous ignition of hydrocarbon fuel-air mixtures occurring ahead of the normal spark-ignited flame front in the engine cylinder. The two-stage mechanism, characteristic of autoignition, incorporates a cool-flame reaction as the first step. Slow, incomplete oxidation and a small temperature rise in the reacting mixture, only 100° to 200° C as opposed to 1,500° to 2,000° C for an ordinary flame, distinguish this reaction. The cool flame appears to sensitize the mixture in the cylinder so that a premature explosion takes place in the unburned portion of the charge. This extremely fast reaction causes a sudden increase in pressure which results in knock. Fuels that do not exhibit cool-flame behavior burn smoothly, without knocking, even at high engine-compression ratios.

By studying the oxidation products of the cool-flame reaction, much can be learned about the early stages of autoignition. If autoignition could be more effectively inhibited, and knock controlled, engines could operate on much cheaper fuels. As the number of automotive units in use continues to grow, the problem of fuel conservation becomes increasingly urgent. Even a slight lowering of the octane rating would result in enormous savings in refining costs and would postpone the eventual depletion of petroleum resources.

Basic Techniques

The procedure for separating and identifying the components from very small amounts of the product mixture incorporates the following basic techniques: use of isotopic tracer methods, gas chromatography, low-temperature distillation, and mass spectrometry. For the over-all process, the oxidized gaseous mixture is separated by low-temperature distillation into four large fractions (according to temperature), the fractions are separated into individual compounds in the appropriate chromatographic column, and then each compound is analyzed using mass spectrometry.

Isotopic propane was chosen as the fuel for study in the autoignition investigations because it has just two kinds of carbon atoms (terminal and middle) and is the simplest hydrocarbon that exhibits typical straight chain hydrocarbon oxidation behavior. By following the path of a labeled carbon (C^{13}), it is possible to note where a molecule of propane divides and how its frag-
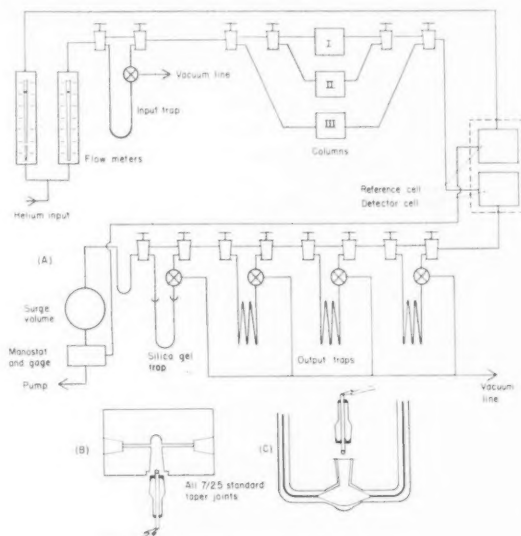

Diagram of chromatography line.

ments combine into new compounds. These isotopic compounds are identified in the mass spectrometer. To narrow the range of conditions that would have to be studied intensively, a preliminary survey using ordinary propane was first made of the various factors that might influence the occurrence of cool flames in propane-oxygen mixtures.

Gas-liquid chromatography, which plays a central part in the procedure, is based on the principle of relative solubility. A helium stream forces the mixture of gases to be separated through a chromatographic column containing, for instance, a finely divided solid, supporting a film of some high-boiling solvent. The gases in the mixture dissolve temporarily along the column, and since they have different solubilities in the column substrate, they are dissolved preferentially

along the way; as a result, the least soluble products emerge from the column first. Gas-solid chromatography works in a similar way, except that adsorption rather than solution takes place. This technique allows separation of pure substances and permits mass-spectrometric identification of the isotopic ratio and C^{13} position in the compounds recovered.

However, since there are too many compounds for a pure separation directly in the chromatographic columns, preliminary separation is achieved in a Leroy-Ward low-temperature still. Using a low-temperature still for fractional distillation not only minimizes side reactions of the more active compounds, but also gives fractions each of which can be further separated on a single appropriate chromatographic column.

To obtain an accurate mass-spectrometric analysis of the isotopic products, it is necessary to separate all the compounds from the final mixture before analysis. Analysis of mixtures of cool-flame products is difficult because of the extremely complex mass spectrum produced. The need for separation is even greater when isotopic molecules are used, since this adds further to the number of closely spaced peaks in the spectrum.

Separation Procedure

The apparatus is constructed as one integral unit including the reaction vessel, low-temperature still, gas-chromatographic line, and vacuum system. The propane-oxygen mixture is admitted to a preheated vessel by expansion, where the reaction takes place. When the cool-flame reaction subsides, the products are passed through a liquid nitrogen trap, where the noncondensable oxygen, methane, and carbon monoxide are separated from the condensable compounds. The noncondensables are separated with a charcoal chromatographic column and collected individually in silica gel traps maintained at liquid nitrogen temperature.

Meanwhile, the condensable products go to the Leroy-Ward still, where they are stored at $-196°$ C. Recovery of reaction-product fractions from the still is accomplished by raising the temperature successively to the values $-140°$, $-60°$, $-40°$, and $+25°$ C; so that four gaseous fractions are produced. The gaseous distillates are collected by steady pumping through a liquid nitrogen trap.

Next, the fractions are removed from the traps one at a time (by warming) and run through a gas-liquid or a gas-solid chromatographic column. A silica-gel adsorption column is used for hydrocarbons and carbon dioxide and a gas-liquid partition column with bis[2-(2-methoxyethoxy)ethyl] ether is used for separation of oxygenated compounds. This ether was the only solvent found that could adequately separate all major oxygen-containing compounds in a single column, using column temperature as the only variable.
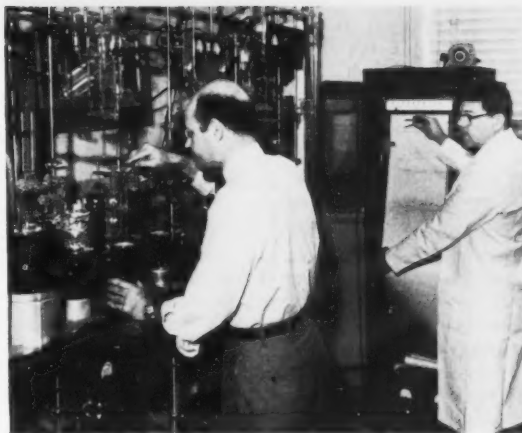
Emergence of each compound from the chromatographic column is indicated by a thermal conductivity-type detector. Possible contamination by overlap with adjacent compounds is eliminated by manipulating stopcocks of the output traps so that only the central portion of each compound is trapped as it comes out of the column. In this way, a purity of about 99.9 percent can be obtained for the smallest samples (roughly 0.1 cm^3 STP).

All samples are collected by diverting the carrier gas flow at the column output into suitable traps cooled by liquid nitrogen. Helium present in the traps is pumped out and the samples are transferred by distillation into stopcock-type collection bottles. Noncondensable compounds are transferred by desorption from collection traps containing silica gel, and readsorption into individual liquid-nitrogen-cooled sample bottles also containing silica gel.

Maintaining a high purity is the main difficulty in transferring small samples from one container to another. Contamination is minimized by preparing the sample bottles with fresh stopcock grease and by thoroughly pumping them out in advance. For best results, the samples must be analyzed in the mass spectrometer as soon as possible.

Because it is difficult to isolate formaldehyde as a gas, direct analysis is not possible. The formaldehyde is therefore converted into carbon monoxide which has the same isotopic content as the original compound.

Several dry runs with ordinary propane were successfully completed before actual isotopic studies were attempted. Since then, three complete series have been run and about 20 major isotopic products, some present in less than 0.1 cm^3 amounts, have been obtained from the analysis. Final interpretation of the results of the tracer experiments is now in progress.

[1] For further technical details, see Separation of the products of cool flame oxidation of propane, by C. R. Yokley and R. E. Ferguson, Combustion and Flame (in press).

# Effects of High Temperatures on Nickel-Copper Tensile Properties

THE Bureau recently investigated the influence of high temperatures on the short-time tensile properties of nickel, copper, and nickel-copper alloys.[1] Results present experimental proof of the prediction, based on dislocation theory, that strain-aging occurs at high temperatures in relatively pure face-centered cubic metals, and becomes more prominent when solute atoms are present.[2]

Alloying has been used for many years to improve the strength of metals. Metallurgists have demonstrated that the strength of alloys depends to a great extent on the strength of the solvent metal, especially in a binary system in which the elements are mutually soluble over the complete range of compositions.

Nickel-copper alloys are often employed when high strength and resistance to corrosion at moderately elevated temperatures are required. For example, these alloys have widespread and diversified uses in chemical, pharmaceutical, marine, power, oil refinery, laundry, textile, pulp and paper, and electrical equipment. Condensers, condenser plates, distiller tubes, evaporator and heat-exchange tubes, and ferrules are manufactured from nickel-copper combinations. Some nickel-copper alloys can be used in sulfur-free atmospheres up to 1,500° F.
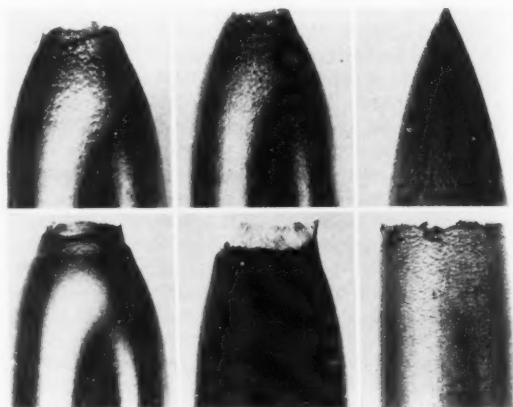

Typical high-temperature specimens as they appeared after fracturing in tension. High-purity nickel (upper row, left to right) was tested at 300°, 900°, and 1,500° F; the 70-percent-nickel–30-percent-copper alloy (bottom row, left to right) was tested at the same temperatures.
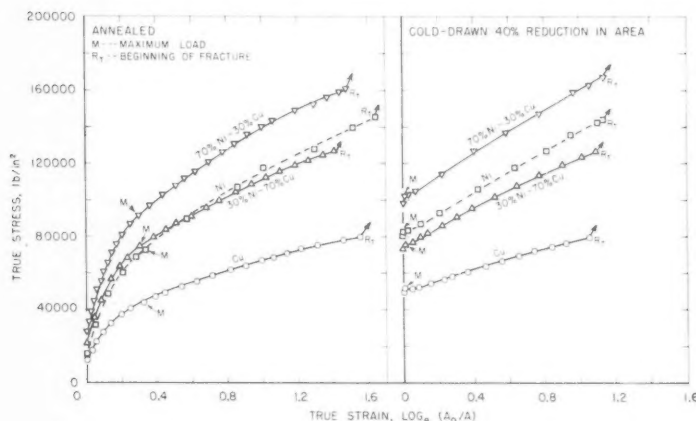
True stress—true strain curves of the specimens tested to fracture at 70° F. Relative positions of the curves indicate the effect of solute atoms on the flow, fracture, and ductility of the different specimens.

The current study is part of a program to evaluate the rheological properties of various metals at sub-zero and elevated temperatures. As copper and nickel form an unlimited series of solid solutions, these materials and their alloys were selected for this study. Factors affecting the behavior in tension at elevated temperatures of solid-solution polycrystalline alloys were evaluated in relation to the behavior of the component metals, each having approximately the same initial grain size (see table).

For use in their experiments, W. D. Jenkins, T. G. Digges, and C. R. Johnson selected annealed and cold-drawn copper, nickel, a 70-percent-nickel–30-percent-copper alloy, and a 70-percent-copper–30-percent-nickel alloy. Short-time tension tests were made at a nearly constant strain rate on round specimens of these materials at temperatures ranging from room temperature to 1,700° F. Additional experiments were made on the annealed copper to find the influence of grain

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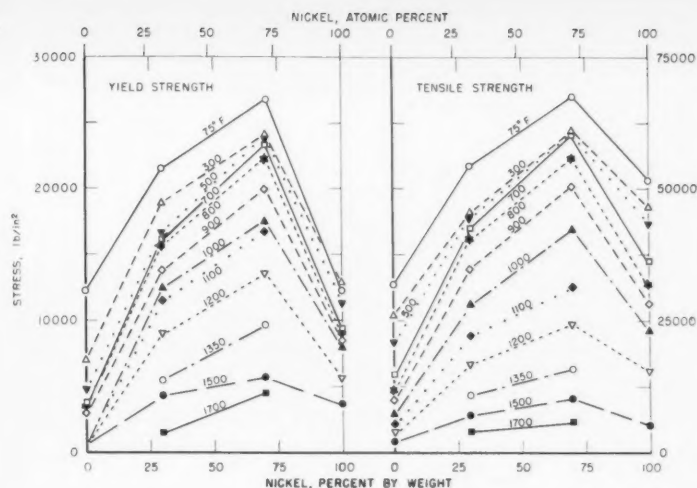
Effect of nickel content and test temperature on the yield strength and tensile strength of initially annealed specimens of the nickel-copper system.

size on the deformation mechanism of this metal at several selected temperatures.

A strengthening effect in the alloys, due to the presence of solute atoms in the crystal lattice of the component metal, was observed at all the temperatures and attained a maximum within the temperature range of 300° to 700° F. The relation between the change in strength and temperature was discontinuous for each of the four materials. This indicated the existence of different deformation mechanisms operating at different temperatures. The ductility of the alloys, as shown by elongation and reduction-of-area values, was usually intermediate between the low values of the copper and high values of the nickel. Serrated stress-strain curves, indicative of strain-aging, were more prominent for specimens of the annealed alloys than for the cold-drawn alloys or for the component metals.

In general, it was found that the effects of cold-drawing on both strength and ductility were either diminished or removed at temperatures above that of recrystallization. Furthermore, it was concluded that the rheological behavior of the copper depended more

on temperature than on initial grain size. The experiments showed that additional lattice defects, created by cold-work, can be annealed out by straining at temperatures above the recrystallization range.

Future work, of interest both from a fundamental and a practical standpoint, will be directed toward an evaluation of the influence of the rate of straining on the mechanisms of deformation at elevated temperatures. The flow, fracture, and ductility of these materials when tested under creep-rupture conditions will be studied.

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[1] For further details, see Tensile properties of copper, nickel, and 70-percent-copper–30-percent-nickel, and 30-percent-copper–70-percent-nickel alloys at high temperatures, by W. D. Jenkins, T. G. Digges, and C. R. Johnson, NBS J. Research 58, 201 (1957) RP2753.

[2] Theory of dislocations, by A. H. Cottrell, Progr. Metal Phys. 4, 205 (1953); Chemical interaction of solute atoms with dislocations, by H. Suzuki, Science Reports, Research Inst., Tohoku Univ. 4, 455 (1952); Dislocations, by J. C. Fisher, Seminar on Impurities and Imperfections, Am. Soc. Metals, p. 28 (1955).

Chemical composition (percentage by weight) of the metals and alloys used as determined by chemical, spectrochemical, and vacuum fusion analyses

Metal	C	Cu	Ni	Co	Fe	Mn	Si	S	Zn	O_2	N_2	H_2	Average [c] grain diameter
													mm
Copper [a] (OFHC)		99.99+											0.025
30% Ni, 70% Cu	0.023	68.84	29.89	0.04	0.50	0.65	0.003	0.004	0.09	0.001	0.001	0.0002	.040
70% Ni, 30% Cu	.017	29.71	70.08	[b]	.01	.01	.12	.002		.001	.001	.0003	.025
Nickel	.007	0.009	99.85	[b]	.04	.03	.11	.002		.002	.001	.0002	.045

[a] The arc spectrum of the copper was examined for the sensitive lines of Ag, Al, B, Be, Co, Fe, In, Ir, Mg, Mo, Na, Ni, Pb, Sb, Si, Sn, Ti, V, and Zn. The lines for Ag, Al, Mg, and Si were identified and there was some indication of the presence of Fe, Ni, and Pb.
[b] Not detected.
[c] Values obtained on specimens prepared from the annealed bars.
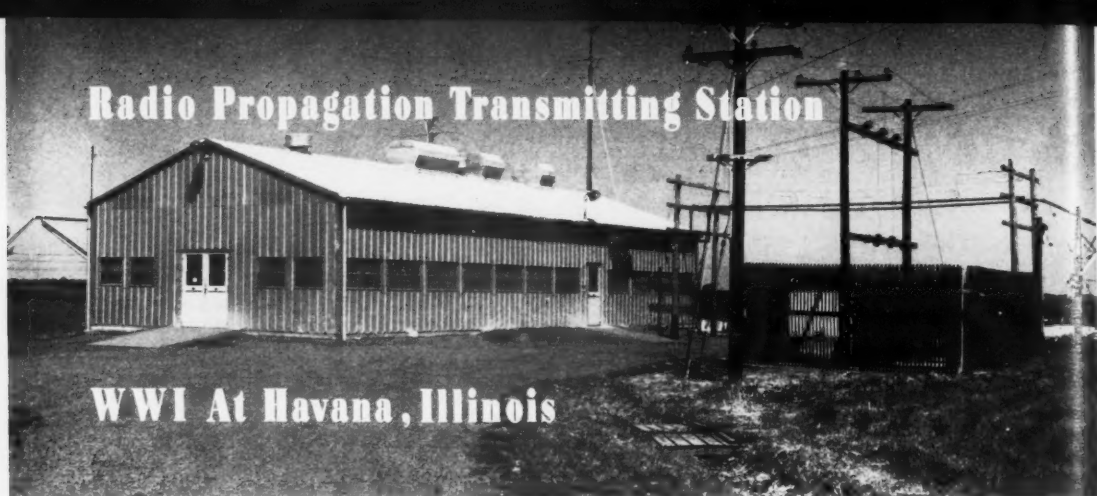
RADIO transmitting station WWI was established in 1956 by the Bureau's Boulder Laboratories, with Edwin F. Florman in charge. The present project leader is Wesley J. Koch. The radio station is located near Havana, Ill., and provides experimental and observatory-type transmissions for radio-wave propagation studies and research and development on radio systems. This particular location was chosen to be roughly central between Boulder, Colo., and the East Coast, and to provide an east-west transmission path to the Boulder Laboratories of approximately 800 miles in length. While intended mainly for use in VHF transmission research programs of the Bureau's Central Radio Propagation Laboratory with transmission directed toward Boulder, Colo., the facilities are available to provide experimental radio transmissions on behalf of other Government agencies or their contractors, to the extent that suitable operating arrangements can be made.

WWI is located on a 160-acre square tract approximately 6 miles south of Havana, Ill. The site is very flat and clear in all directions for at least a mile. The building that houses the transmitters is located near the center of the site, and the various antenna systems occupy most of the remaining area. The geographical coordinates of the center of the site are 40° 13.27′ N., 90° 1.39′ W. The Boulder Laboratories recently designated WWI as its Long Branch station—not Havana— to avoid confusing its location with Havana, Cuba.

There are at present twelve transmitters located at the Havana station, ranging in power from 3 to 50 kw, and operating on frequencies from 30 to 108 Mc. Eight of these transmitters were designed and constructed by the Bureau. The remaining four transmitters as well as two power amplifiers are standard commercial units. All transmitter operating frequencies are controlled by high-precision frequency standards located in a screen room. The outputs of the standards are fed to frequency multipliers located in a centralized control position, where the operation of all transmitters is monitored and controlled. An automatic keying system is located in the control position which provides simultaneous half-hourly identification-keying of all the transmitters. Keying is accomplished in the fre-

quency multipliers for the transmitters. After the transmitters have been identified, each half hour they are keyed off for 2 min to allow the receiving station equipment to record the level of the received noise.

Most transmissions from the WWI transmitters are 24-hour-per-day unmodulated type A-0 emissions; however, there are intermittent periods of various types of modulation on one or two frequencies.

The present antenna systems consist of six horizontal rhombic antennas, five tilted Yagi antennas, and three horizontal Yagi antennas. All of the horizontal rhombic antennas are of similar design, scaled according to operating frequencies. They have a plane-wave gain of approximately 18 db, relative to a half-wave dipole, with the axis of the main lobe inclined at an angle of 4.6° above the horizon. The beam width is approximately 6° to the half-power points in horizontal and vertical planes. The approximate operating frequencies for the rhombic antennas are 30, 40, 50, 74, and 108 Mc.

The tilted Yagi antennas are inclined 40° above the horizontal. This tilt was used to provide a very broad vertical radiation pattern from these antennas. The antennas consist of five elements each, and are mounted 2.4 wavelengths above the grounds. The free-space gain is approximately 9 db relative to a half-wave dipole. The approximate operating frequencies for these antennas are 30, 50, 74, and 108 Mc.

The horizontal Yagi antennas are similar in design to the tilted Yagi antennas; however they are mounted 2.12 wavelengths above ground. These antennas are designed to operate at approximately 30, 50, and 74 Mc.

The outputs of all the transmitters are carried in coaxial lines inside the transmitter building. A coaxial switching system is provided so that some of the transmitter outputs may be conveniently switched between antennas. The use of coaxial lines keeps the stray radio frequency power inside the building to a minimum.

Outside the building 600-ohm open wire transmission lines are used to feed the rhombic antennas. A balun and matching section are connected between each open-wire transmission line and the coaxial line entering the building. The Yagi antennas, for the most part,

are fed with 200-ohm open-wire transmission lines, and have baluns connected between the 200-ohm lines and the coaxial lines entering the building. The ends of the horizontal open-wire transmission lines are insulated by shorted quarter-wave stubs, or "metallic" insulators. The shorted ends of the stubs are grounded to afford lightning protection. Shorted stubs are also used at the antenna end of each transmission line to obtain an almost perfect match of load impedance to characteristic impedance on the lines.

Research programs now using the facilities of the Havana station include studies of several interesting mechanisms of radio-wave propagation. Transmissions on the rhombic antennas at five different frequencies are used to study the frequency dependence of propagation by scattering in the lower ionosphere. Studies of modulation techniques for utilizing scatter propagation to best advantage are also being made from transmissions on the rhombic antennas. Transmissions on the tilted Yagi antennas are being used to study radio-wave propagation by reflections from ionized meteor trails. The horizontal Yagi antennas are used in studies of sporadic E transmissions.

Supplement to Radiation Handbooks
Summarizes New Recommendations on Maximum Permissible Dose

AN 8-page supplement to the National Bureau of Standards Handbooks [1] dealing with radiation protection and related matters has been prepared by the National Committee on Radiation Protection and Measurements (NCRP). Entitled *Maximum Permissible Radiation Exposures for Man*, the supplement summarizes the new recommendations of the NCRP on safe limits of radiation exposure; it extends and clarifies the Preliminary Statement issued by the Committee in January 1957.[2] The new publication introduces only minor changes and is intended to be in general conformity with the philosophy expressed in the April 1956 statements of the International Commission on Radiological Protection (ICRP).[3]

The recommendations of the NCRP, an advisory group of experts in various phases of the radiation field, are regularly published in the NBS Handbook series. Several of these Handbooks are now being revised to bring them into conformity with the new recommendations. Pending the availability of the revised Handbooks, the present supplement provides a simplified statement of the changes needed to comply with the new recommendations.

Further details on the new supplement are given in the following excerpts from its introduction.

Excerpts from NCRP Statement

On January 8, 1957 the National Committee on Radiation Protection and Measurements issued a Preliminary Statement setting forth its revised philosophy on Maximum Permissible Radiation Exposures to Man.[2] Since that time, several of the NCRP subcommittees have been actively studying the necessary revisions of their respective Handbooks. These studies have shown the need for (1) clarification of the earlier statement and (2) modification or extension of some of the concepts in that statement. Furthermore, the ICRP has made minor changes in their recommendations. Accordingly, the NCRP has prepared a set of guides, given below, that will assure uniformity in the basic philosophy to be embodied in the several Handbooks. Since many of the Handbooks are followed closely in planning radiation operations in the United States, and since the modification of a Handbook may require many months of effort, it seems wise to make the over-all guiding principles available in advance of the reissuance of the revised Handbooks. These guides are not designed to take the place of any of the Handbooks; the principles given below will be extensively treated later in appropriate places. In the meantime, Handbook revisions or supplementary statements will be issued as rapidly as possible. . . .

The changes in the accumulated MPD (Maximum Permissible Dose) are not the result of positive evidence of damage due to use of the earlier permissible dose levels, but rather are based on the desire to bring the MPD into accord with the trends of scientific opinion; it is recognized that there are still many uncertainties in the available data and information. Consideration has also been given to the probability of a large future increase in radiation users. In spite of the trends, it is believed that the risk involved in delaying the activation of these recommendations is very small if not negligible. Conditions in existing installations should be modified to meet the new recommendations as soon as practicable, and the new MPD limits should be used in the design and planning of future apparatus and installations. Because of the impact of these changes and the time required to modify existing equipment and installations, it is recommended on the basis of present knowledge that a conversion period of not more than 5 years from January 1957 be adopted, within which time all necessary modifications should be completed.

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[1] *The supplement is being supplied with the following NBS Handbooks:* H42, Safe handling of radioactive isotopes (20¢); H48, Control and removal of radioactive contamination in laboratories (15¢); H49, Recommendations for waste disposal of phosphorus-32 and iodine-131 for medical users (15¢); H51, Radiological monitoring methods and instruments (20¢); H52, Maximum permissible amounts of radioisotopes in the human body and maximum permissible concentrations in air and water (25¢); H53, Recommendations for the disposal of carbon-14 wastes (15¢); H54, Protection against radiations from radium, cobalt-60, and cesium-137 (25¢), [*Note: H56 has been superseded by H65, Safe handling of bodies containing radioactive isotopes* (15¢): *H65 embodies all recent changes and does not need the supplement*]; H55, Protection against betatron-synchrotron radiations up to 100 million electron volts (25¢); H56, Safe handling of cadavers containing radioactive isotopes (15¢); H58, Radioactive-waste disposal in the ocean (20¢); H59, Permissible dose from external sources of ionizing radiation (30¢); H60, X-ray protection (20¢); H61, Regulation of radiation exposure by legislative means (25¢). *These Handbooks are available at the indicated prices per copy from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.*

Present holders of the above Handbooks can secure copies of the supplement by writing to the Publications Section, National Bureau of Standards, Washington 25, D. C.

[2] Maximum permissible radiation exposures to man. *NBS Tech. News Bul.* 41, 17 (Feb. 1957).

[3] Report on 1956 amendments to the recommendations of the International Commission on Radiological Protection (ICRP), *Radiology* 70, 261 (Feb. 1958).

A LABORATORY prototype machine for the automatic high-speed sorting of letter mail has been developed by the Rabinow Engineering Co. under a contract arranged and supervised by the Bureau for the Post Office Department. The machine is designed to sort at the rate of 36,000 letters per hour into as many categories as may be needed. Sorting can be directed either by a built-in electronic control, by human operators, or by a combination of both. The system is of modular design and thus adaptable to the varying needs of different post offices, with regard to both sorting complexity and spatial requirements. The machine has proved successful in laboratory tests, and the Post Office Department has recently let a contract for the construction of a 1,000-pocket production prototype to be used in a post office.

For some time the Post Office Department has been seeking mechanized sorting methods to assist its personnel in keeping up with the continuing rapid growth of letter mail. Because of its specialized experience with data-processing machines and electronic equipment, the Bureau has been aiding the Post Office on various mechanization problems. The Bureau has been developing methods and machines to speed the handling of mail. Much of the equipment development and nearly all construction have been placed in the hands of private industry.

Two basic problems are involved in mechanized letter sorting. One is concerned with the information content of the address and with the mechanics of the control that must be provided by some computer-like device for directing the mail sort. The other problem is concerned with the physical handling of the mail. Today's envelopes and their contents are obviously not designed for mass handling by machine. This fact complicated the design of the present machine. If standardized envelopes and addresses could eventually be made acceptable for wide-scale use, the task of the machines would be much easier and cost reduced.

Automatic S[...]
For [...]

Work on these problems at the Bureau has proceeded along several lines. Data have been and are being collected in representative cities to form an engineering basis for the system and machine design. These data include such items as the general nature of the mail, i. e., the size and shapes of envelopes, the percentage of handwritten versus typewritten mail, and the range of color of envelopes: the number of letters handled each day and their distribution by times of day; and the nature of distribution of local mail and outgoing mail. Studies are underway on methods of converting the written or printed address into a code printed on

Below left: Over-all view of the laboratory prototype machine [devel]oped for [sorting] letter mail. It consists essentially of a large number of pockets [on an] endless [conveyor] (below right). Each of the 12 wheels accompanying each po[cket can] be sh[own, giving] a total of 2^{12} or 4,096 combinations. As the conveyor move[s and] set o[r when] the correct destination is reached, all of the wheels drop into [po]sitions a[nd ...]
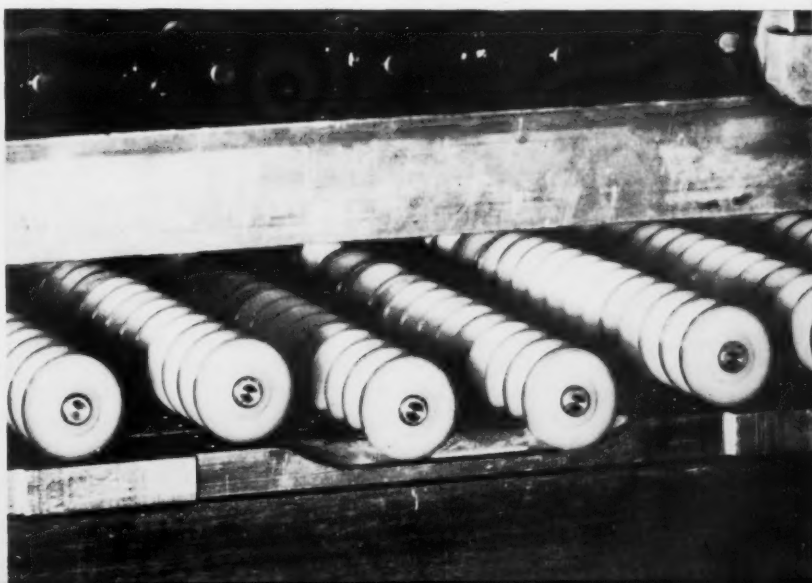
As the conveyor moves, each set of 12 wheels rolls over tracks designed so that when the correct destination is reached all of the wheels drop into depressions and the letter is released.

The mechanical sorting and coding of letter mail begins at the code printer. Here letters from a stack of "faced" mail, moved by a conveyor belt, are picked off one at a time and mechanically placed in a reading-and-coding position in front of an operator. He reads the addresses, abbreviates their important parts, and types these abbreviations on the back of the envelope by means of a special printer.

The print coding is in a binary form, requiring 6 bits for each alphanumeric character. For outgoing mail, the coding operator may merely abbreviate the city and the state. The choice depends on whether all the coding is to be done at the initial location or part of the coding at the final destination, and on whether the city to which the letter is addressed is or is not equipped with automatic machinery. In sorting for local distribution, the city need not be mentioned, and only the street number and street name will be coded. In any case, not more than 64 bits would be required for the entire abbreviated address.

The operator then chooses, by push-button operation, one of four possible destinations—local, outgoing, airmail, or miscellaneous—and sends the coded letter through its first sort. The mechanism actuated by the push button opens a trap door and sets a directing vane so that the coded letter drops into the proper pre-sort when it is released from the code printer.

It is expected that only a few seconds will be required to code an average letter. This operation may ultimately become the only human one in the entire sorting process. The reading head of the code reader is physically located in the reader-feeder-inserter mechanism immediately preceding the point where the letter is dropped into the conveyor. The sorting system is organized so that when adequate automatic reading

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the envelope either with visible or invisible inks, or with magnetic materials. Development of special phosphorescent inks for this use is also in process.

The sorting machine developed by the Rabinow Engineering Company consists essentially of a large number of pockets on an endless conveyor and electromechanical equipment that controls the dropping of a letter from a pocket into a specific fixed receptable. Accompanying each pocket on the conveyor is a steel rod carrying 12 nylon wheels. Each wheel can be shifted laterally on the rod into one of two positions. Thus, there are 2^{12} or 4,096 combinations of wheel positions.

machine ped for the Post Office for the automatic high-speed sorting of of pockets endless conveyor (below center), with associated code wheels g each poche shifted laterally on the rod into one of two positions, giving yor move set of 12 wheels rolls over tracks designed so that when drop into sions and the letter is released.

machines become available they can be incorporated into the sorter with a minimum of alteration.

An electronic directory (sometimes called memory or translator) receives the coded, abbreviated address from the code reader, "looks up" the sorting destination for each address, and controls the delivery of the letter to that destination receptacle. The electronic-directory output drives the code wheel setter, which sets each group of code wheels on the conveyor carts, to the appropriate coded arrangement to drop each letter in its final sort receptacle. The entire sequence involved in looking up the destination and setting the wheels is accomplished in approximately one-tenth of a second.

Destination receptacles at bottom of machine into which letters are sorted. Under the present design, there could be up to 4,096 such receptacles if the machine were extended to be large enough.

The electronic directory is an electromechanical-optical device specially designed to meet the requirements of the sorting machine. It converts, according to a pre-arranged schedule, the information in the 64-bit code of the abbreviated address on the envelope into a 12-bit code corresponding to the receptacle where the letter is to be dropped by the conveyor. The directory consists of a stack of 64 thin plates of stainless steel, each approximately 1-ft square. Each plate has etched into it 40,000 small round holes, about one-thirtieth of an inch in diameter, spaced on $\frac{1}{16}$-in. centers. The plates are so suspended that they can be moved by an electromagnet from left to right one-sixteenth of an inch. The plates are initially covered with an opaque black ink that fills the holes completely. Some of the holes are punched out to provide the directory with its address conversion data. Each plate corresponds to a dot position of the binary address code. If the code contains the full 64-dot positions, and if, by convention, each plate moves to the right if the dot is present and remains stationary if the dot

is absent, each address will cause the plates to move into a unique set of positions.

Behind this set of plates are located 12 phototubes, each of which sees an area of roughly 3 by 4 in. of the plate stack. These areas do not overlap. In front of the plates is a source of light that illuminates the whole area of the plate stack. Removing the ink from certain of the holes in each plate to permit the light to reach any desired combination of phototubes creates a function table that converts a 64-bit input into a 12-bit output. This 12-bit output is the control for setting the 12 wheels that accompany each letter in the conveyor.

Etching holes in the plates and then filling them with ink ensures an accurate position for each final hole so that any set of 64 corresponding holes in the stack will line up. The directory contains approximately 1.5 million bits and no trouble with mechanical alinement of the holes has been experienced so far. The plates can be moved easily in one-tenth of a second, thus keeping up with the rate of the sorting conveyor. This type of optical directory can also be used as any general-purpose function table. A much larger number of holes per plate, larger plates, or several sets of plates in parallel could be used and many variations of the basic scheme are possible. The memory in its present form could handle a city of 100,000 to 200,000.
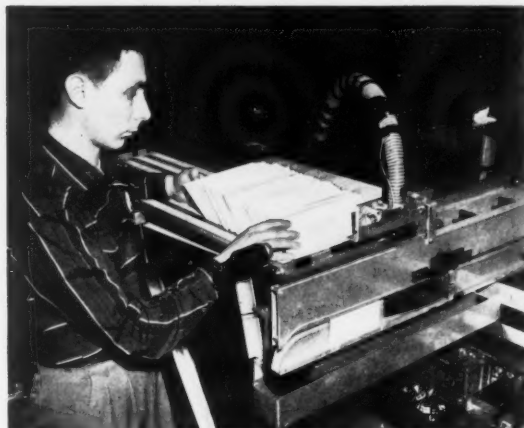
Top of machine where coded mail is placed in machine. An electronic reader scans the dot code and controls the delivery of the letter to a particular destination receptacle.

Each letter is inserted by the reader-feeder-inserter into a separate pocket on the conveyor. At the same time the code wheels for each pocket are set according to the output of the directory so that its letter will be deposited into the proper final sort receptacle. A code wheel resetter returns all code wheels to their "zero" position following the dropping of the letter into the receptacle. The empty pockets are then reloaded and their corresponding code wheels are set for another sort.

In a less-complex version of the machine, letter sorting is controlled by human operators instead of the equipment which reads the dot code printed on the envelope. The operators sit beside the conveyor belt, and letters are delivered to them automatically. Each operator reads the address, decides which receptacle of the conveyor the letter is to go into, and depresses a combination of keys. This operation sets the position of the wheels accompanying the pocket into which the letter will be dropped. At no time does the oper-

Code Printer. Letters, one at a time, are presented to the operator who reads the addresses, abbreviates their important parts, and types these abbreviations on the backs of the envelopes by means of a special printer. The print coding is in binary form, and appears in the form of "dot" or "no dot" on the envelope.

The electromechanical-optical directory shown here converts, according to a prearranged schedule, the information in the 64-bit code of the abbreviated address on the envelope into a 12-bit code corresponding to the receptacle where the letter is to be dropped by the conveyor.

ator touch the letter. Such a machine can sort mail at rates as fast as 1 per second for each operator. It is expected that the initial version of the machine will sort letters at the approximate rate of 10 per second, thus requiring 10 to 12 operators.

The sorting conveyor can be built in small modules so that machines of various sizes can be constructed to suit the particular size of the post office or of the sorting system used. The conveyor can be assembled in many layers so as to best utilize the available space in a particular building. Because the letters are carried vertically, and their motion is perpendicular to

their faces, the over-all speed of the conveyor can be kept low. Gravity drops are employed both for placing the letters into the conveyor and for removing them from the conveyor into their final receptacles. Considerable effort was spent to design the machinery in such a way that the "facing" of the letters will be preserved, that is, that the addresses on the envelopes will still face in the same direction after being sorted. Thus, refacing will not be necessary for any subsequent processing.

Special provisions are being made to enable the conveyors to be stacked in various arrays so that the letters can transfer from one conveyor to another for multiple sorting. The Bureau is making studies to find systems of sorting mail that will be economical both in cost of machinery and in the effective employment of operating personnel. It is possible to sort letters by short conveyors and use several successive sorts, or to use long conveyors and fewer sorts, or combinations of short and long conveyors so that some mail is sorted only once while other mail is sorted more often, depending on the volume and statistical distribution. Many of the factors involved in system design are difficult to evaluate, for example, the repeated handling of envelopes not designed for machine use as compared to the cost of large machinery where the letter need be handled only once. Actual experience with these machines in a post office should help to settle such problems in the next few years.

Color Response of the Human Eye

TO further the development of color standards and measurement methods, the Bureau has been participating in an international study of color vision. Purpose of the study, sponsored by the International Commission on Illumination,[1] is to define the color response of the average human eye. Pertinent physical properties of color standards can be measured by strictly physical methods; however, to compute a valid numerical specification of a perceived color from the physical measurements requires a determination of the eye's color response, technically expressed as "color-mixture functions."

A recent experiment for this study provides an approximate method for measuring the pigmentation that affects color judgment. The experiment confirmed the belief that the amount of lens pigmentation increases as a person grows older, but it showed that macular pigmentation remains relatively constant with age.[2] Results of the experimental data, evaluated by K. L. Kelly of the colorimetry laboratory, are expected to be of value in determining the eye's color-mixture functions.

The pigmentation that affects color vision in the normal eye occurs only in the lens and macula. The macula is the so-called "yellow spot" in the center of the retina. The iris, which gives the eye its external color—for instance, brown, gray, blue—is opaque, and does not affect color judgment. It is well known that the lens becomes yellower as a person grows older, but no method has been available to estimate the amount of yellowing either in the lens or in the macula. By utilizing a pair of metameric gray plaques devised by W. C. Granville,[3] the investigators were able to measure the pigmentation present in the eyes of 39 persons with normal color vision, ranging in age from 18 to 77 (see table).

In color-vision test, observer views two sample plaques from a near position through a daylight filter. The near position is one at which the plaques subtend a visual angle of 10°.
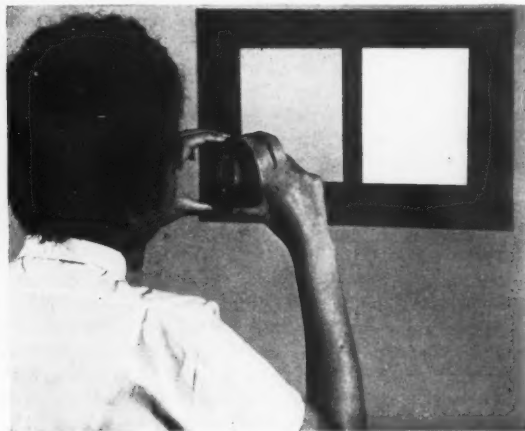
The Experiment

One of the plaques, a "simplex" gray, was produced by a mixture of white and black pigments, and the other, a "complex" gray, by a mixture of yellow, green, purple, and white pigments. When a person of "average" color vision views these plaques in daylight from a near position, the simplex gray appears redder than the complex gray. The near position is one at which the plaques subtend a visual angle of 10°. When the observer steps back a few paces to a position from which the samples subtend a visual angle of 2°, the simplex gray then appears greener than the other.
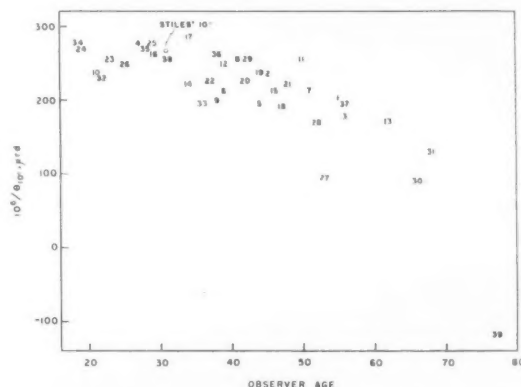
Reciprocal color temperature of source required in a 10° field to produce red-green balance between the Granville grays, plotted against observer age. The plotted points are represented by the numbers used to designate 39 different observers. It is apparent that older observers require lower reciprocal color temperatures. This is ascribed to the known increase in lens pigmentation with age.

This phenomenon occurs because the retinal image of the samples at the 10° position covers both the macula and a large portion of the surrounding retina, while at the 2° position the retinal image falls wholly within the eye's macular pigment, which is yellow. The effect is somewhat analogous to placing a yellow filter in front of the eye for the 10° position, thus reducing the color temperature of the light source, that is, making it redder. Consequently, the 10°-field results depend primarily on the lens pigmentation and the 2°-field results depend not only on the lens but to a large extent on the macular pigmentation.

In the experiment, each observer viewed the two samples side by side at the 10° position. The color temperature of the light source was then reduced until neither sample appeared redder or greener than the other. This point was called the crossover point, and was recorded as the reciprocal color temperature in

Observer	Sex and age	Eye color	Hair color	Color of simplex relative to complex		Reciprocal color temperature of match point (μrd)		
				10°	2°	10°	2°	Difference
1	M55	blue	brown	red	green	204	91	113
2	M45	hazel	brown	red	green	238	103	135
3	F56	brown	brown	red	green	179	47	132
4	M27	hazel	dark brown	pink	pink	278	196	82
5	M44	blue	brown	red	green	196	84	112
6	F39	blue	dark brown	red	green	213	132	81
7	M51	dark brown	black	slightly pink	green	213	78	135
8	M41	blue	blond	pink	green	256	149	107
9	M38	blue	red	pink	green	200	110	90
10	M21	hazel	auburn	pink	green	238	84	154
11	F50	hazel	brown	pink	slightly pink	256	189	67
12	M39	blue	blond	pink	pink	250	179	71
13	M62	blue	brown	pink	green	172	118	54
14	M34	blue	brown	red	green	222	135	87
15	M46	blue	brown	pink	green	213	71	142
16	M29	dark brown	black	pink	green	263	182	81
17	M34	dark brown	black	pink	pink	286	213	73
18	M47	blue	brown	match	green	189	65	124
19	F44	brown	dark brown	pink	green	238	159	79
20	M42	brown	brown	pink	match	227	149	78
21	M48	brown	brown	pink	green	222	175	47
22	F37	dark brown	dark brown	lavender	green	227	127	100
23	F24	brown	brown	pink	pink	256	164	92
24	F19	brown	brown	lavender	lavender	270	208	62
25	F29	blue	brown	red	match	278	154	124
26	F25	hazel	light brown	lavender	match	250	170	80
27	M53	blue	brown	match	green	95	−14	109
28	M52	brown	brown	match	green	170	−2	168
29	F42	dark brown	dark brown	pink	slightly pink	256	175	81
30	M66	blue	brown	green	green	91	−40	131
31	M68	blue	brown	green	green	130	−28	158
32	M21	hazel	blond	red	green	233	110	123
33	M36	blue	blond	red	green	196	29	167
34	F18.5	hazel	brown	pink	pink	278	170	108
35	M28	green	blond	pink	pink	270	161	109
36	M38	brown	light brown	pink	pink	263	192	71
37	M56	blue	brown	red	green	196	84	112
38	M51	dark brown	black	pink	pink	256	182	74
39	M77	blue	brown	green	green	−118	<−118	>100
Averages	41.3					211	<111	>100

microreciprocal degrees (μrd) of the source. The test was repeated at the 2° position. The reciprocal color temperature at each position was then plotted against age of the observer.

Results

The observers were classified into five groups: (1) Red-red; (2) red-match; (3) red-green; (4) match-green; and (5) green-green. The youngest observers, considered to have the least lens pigmentation, described the simplex gray as redder than the complex gray at both the 10° and the 2° positions. These observers were put into group 1. Those in group 2, with a little more pigmentation, said the simplex appeared redder at the 10° position but that it matched the complex at the 2° position. Group 3, which included most of the observers, described the simplex as redder at the 10° position and greener at the 2° position than the complex gray. Group 4, with still more lens pigmentation, said the simplex matched the complex at the 10° position but that it was greener than the complex at the 2° position. Several of the observers, including the older ones, were considered to have the most pigmentation because they saw the simplex greener at both positions. They were put in group 5.

The reciprocal color temperature of the source required to produce a red-green balance between the Granville grays was found to vary widely from one observer of normal color vision to another. However, the crossover value of reciprocal color temperature for any one observer serves to characterize his color vision in an approximate but useful way. The value (of reciprocal color temperature) required in a 10° field for red-green balance is tentatively taken as a measure of the yellow pigmentation in the lens of the observer's eye. Similarly, the value required in a 2° field for red-green balance of the Granville grays is a measure of both lens and macular pigmentation. The difference in these two values (value for 2° field minus value for 10° field) is tentatively taken as a measure of the macular pigmentation of the observer.

The tentative measure of lens pigmentation afforded by the Granville grays correlated well with the age of the observer, but the tentative measure of macular pigmentation showed no correlation with age. Neither measure showed significant correlation with the color

of the iris or of the hair. Of the 39 persons studied, 11 were female.

The color of the eyes of all the observers ranged from blue through hazel, light brown, brown, dark brown, to almost black; hair color ranged from ash blond through red, light brown, brown, dark brown to black. It was interesting to note that among the "red-red" observers—those with the least lens pigmentation—a number had heavily pigmented skin, irises, and hair.

Results of the tests were compared with four statistical definitions of a standard observer. The comparison showed that the three standard observers compiled in recent years were not superior for the $2°$ observation to the CIE standard observer recommended in 1931. However, data on a specific age group for the $10°$ standard observer developed by Dr. W. S. Stiles [4] of the National Physical Laboratory in England agreed very well with the average of the actual observers in the same age group in the present experiment.

Further work is scheduled to obtain color responses on textile and vitreous enamel samples. Data derived from these studies will be correlated with the work now being performed by Dr. Stiles in England and the combined results will be evaluated for a possible revision to the 1931 CIE standard observer.

[1] Frequently referred to as either the CIE or the Commission Internationale de l'Eclairage.
[2] For further technical details, see Observer differences in color-mixture functions studied by means of a pair of metameric grays, by Kenneth L. Kelly, J. Research NBS, 60, 97 (1958) RP2825.
[3] Metameric color and the macular pigment, by W. C. Granville and D. B. Judd, J. Opt. Soc. Am. 39, 632A (1949).
[4] Interim report to the Commission Internationale de l'Eclairage, Zurich, 1955, on the National Physical Laboratory's investigation of colour-matching, by W. S. Stiles Optica Acta, 2, 168 (1955).

Impurities in the Electrorefining of Molybdenum
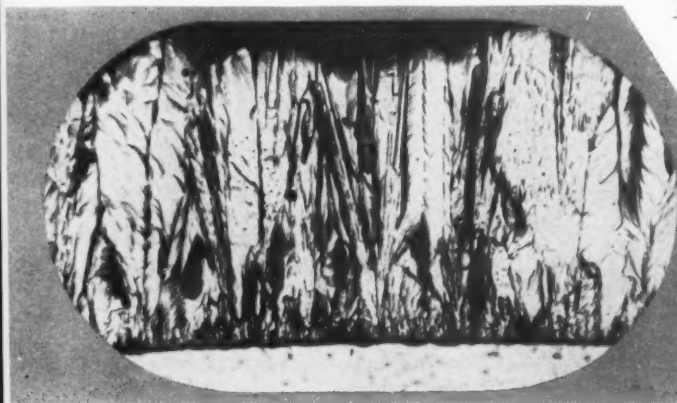
THE Bureau has been investigating the electrorefining of molybdenum for the Navy Bureau of Ordnance, to determine the extent to which contaminating metallic ions are plating with this metal.[1]

Molybdenum appears to have great potentialities for aeronautical use in jet engines and turbines because of its advantageous high-temperature characteristics. At the temperatures produced by high-energy fuels, most metals deform beyond tolerance limits. Molybdenum, however, retains sufficient tensile strength to allow its use above $1,000°$ C.

As part of a general research program on the electrodeposition of heat-resistant materials, the successful electrolytic preparation of molybdenum was achieved in 1954.[2] The metal was electrodeposited from a solution of potassium hexachloromolybdate (K_3MoCl_6) in molten alkali halides.

In the present experiments, which were conducted by D. E. Couch and S. Senderoff of the electrodeposition laboratory, the effects on the plating process of tin, copper, iron, silicon, and nickel—the most common impurities associated with molybdenum—were studied.

Each of the metal contaminants was added to the original basic bath as a soluble salt (stannous, ferrous, cuprous, and nickel chlorides; silica, and sodium hexafluosilicate), in concentrations of 0.1, 1, and 10 percent by weight. No deposit was prepared from baths containing more than one of the metallic salts, but control deposits were obtained from the uncontaminated bath.

In investigations with these fused salts, molybdenum was found to deposit onto the cathode before any of the other metals present. Further experiments showed that under the proper plating conditions all the metals studied except nickel, which tends to codeposit, can be removed successfully from molybdenum by electrorefining.

Above is micrograph (magnified 100 times) of a molybdenum deposit obtained from a bath at $900°$ C containing 10-percent sodium fluosilicate. A current density of 30 amp/dm^2 was used. Smooth, coherent deposits up to 0.02 in. thick were produced under these conditions. Smooth plating was maintained with concentrations up to 20 percent by weight.

Diagram of apparatus used in electrorefining molybde-
num. Deposition is conducted within a 3.5-in. internal
diameter graphite crucible (B) containing the molyb-
denum anode (C) and set in an airtight glass container
(D). Entrance chamber (A) permits removal of the
cathode and insertion of a new cathode without exposing
the system to air.

To vary operating conditions, four different current
densities (3, 10, 30, and 100 amp/dm^2), were run at
each of two temperatures, 600° and 900° C. In this
way eight electrodeposits could be prepared after each
addition of a single contaminant.

Optimum conditions for molybdenum-refining re-
sults were found to be 900° C and 3 amp/dm^2. Since
nickel has a deposition potential close to, but some-
what higher than that of molybdenum, the low-current
density enables the molybdenum to plate out alone.
With high voltage, both potentials are reached and thus
both metals deposit simultaneously. The importance
of high temperature for effective electrorefining may
be related to the temperature polarization. At the
higher temperature, molybdenum is electrodeposited
at a lower potential and therefore better refining results.

Analysis of the stannous chloride bath showed that
only traces of tin were deposited with the molybdenum
at high temperature and low-current density. This is
significant at higher concentrations when there is
actually more tin than molybdenum in the bath. Sim-
ilarly, only small amounts of copper were incorporated
in the deposits at 900° C, even when the mole ratio
of copper to molybdenum in the bath was about 5 to
1. However, copper impurities did produce a slightly
darker molybdenum than the control deposits.

In the series of runs with ferrous chloride, iron was
completely separated from molybdenum with neither
an appreciable loss of iron from the bath nor a deposit
on the cathode at higher temperatures. Iron gradually
accumulated in the electrolyte when in the ferrous form,
as was expected, but only traces of the metal were
detected in the deposit.

Because silicate compounds are found in molybdenum
ore, silica gel and sodium hexafluosilicate were added
separately to the bath in the experiments. The finely
ground gel coated the cathode in an irregular fashion.
Easy removal of this silica by physical instead of chem-
ical methods indicates that it deposited independently
of the molybdenum rather than as an integral part of
the cathode deposit. However, large quantities of sus-
pended free silica in the bath could cause difficulty in
electrorefining, since small accumulations of granules
might then be interspersed throughout the molybdenum
deposit.

When sodium fluosilicate was used as the additive, no
increase in the silicon content was noted. However, an
unusual effect occurred at high temperatures with a
fluosilicate of 10 percent by weight; smooth, coherent
deposits could be built up to 0.02 in. before becoming
rough. Deposits made at 600° C. from this bath were
black and powdery.

At lower concentrations, the addition of nickel chlo-
ride produced little change at the cathode but at higher
concentrations (10% and up), semibright, smooth
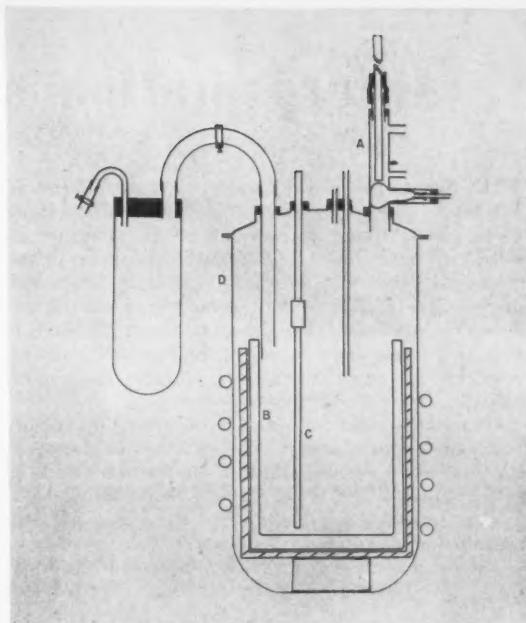
Mo-Ni codeposits were observed. It was concluded
that nickel could be a serious contaminant in molybde-
num electrorefining, but that it probably could be main-
tained at an unobjectionable concentration in the bath
by occasionally electrolyzing it at a lower temperature
and current density, under which conditions nickel is
preferentially deposited and removed from the bath.

[1] For further technical information, see Electrorefining
studies in the presence of tin, iron, copper, silicon, and
nickel, by D. E. Couch and S. Senderoff, Trans. Metal.
Soc. AIME, **212**, 320 (1958).
[2] The electrolytic preparation of molybdenum from
fused salts, by S. Senderoff and A. Brenner, J. Electro-
chem. Soc. **101**, 16 (1954).

Addendum to NBS Handbook 54

A 2-page addendum has been issued for NBS
Handbook 54, *Protection Against Radiations
from Radium, Cobalt–60, and Cesium–137.* The
addendum is intended as an interim statement of
some of the changes and additions to be incorpo-
rated in the new edition of the Handbook now
being prepared. The revisions relate to the new
recommendations on maximum permissible dose
recently announced [1] by the National Committee
on Radiation Protection and Measurements
(NCRP); the design of teletherapy apparatus;
and radiation hazards resulting from fire. Hold-
ers of NBS Handbook 54 can obtain copies of the
addendum by writing to the Publications Section,
National Bureau of Standards, Washington 25,
D. C.

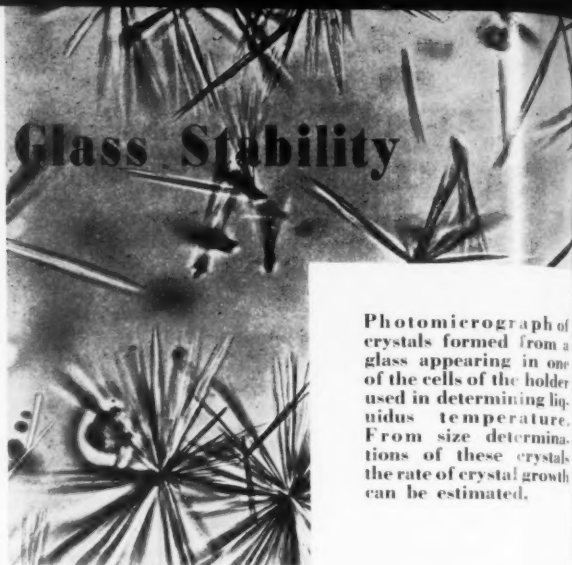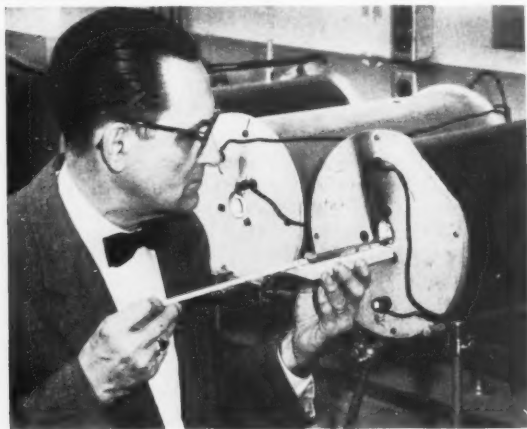[1] See Supplement to radiation handbooks, p. 155, this issue.

Interpretation of Glass Stability

THE Bureau has recently analyzed glass stability in terms of phase diagrams, shedding additional light on the glass-forming process and on the structure of multicomponent glasses.[1] This work contributes to the present glass theory by indicating that distinct chemical entities exist in glass. Of practical use as well is the related finding that stable glasses are usually found in areas of a phase diagram where the liquidus curve or surface is flat—an indication of a highly dissociated compound.

Since stable glass formation is directly opposed to crystallization or devitrification, studies of glass stability include a determination of the factors affecting crystallization. One is the liquidus temperature—the highest temperature at which molten glass and the crystalline phase can coexist in equilibrium; another is the rate of crystal growth at various temperatures; a third is the seeding or nucleation time required for crystal growth to start. In the present research by G. W. Cleek and E. H. Hamilton of the glass laboratories, the liquidus temperature was determined for various compositions so that liquidus curves could be plotted. A comparison of liquidus data with observed glass-forming ability provided a basis for structural interpretation.

In the experimental part of this work, glasses of the following types were investigated: barium borosilicate, sodium titanium silicate, barium titanium silicate, zinc borosilicate, barium lanthanum silicate, barium tantalum silicate, and calcium aluminate glasses. Studies were also conducted on more complicated glasses made by introducing other oxides, including the rare earth oxides, into these simpler glasses.

Placing a glass-containing holder in a temperature gradient furnace. Observations of the melted glass allow liquidus temperature and rate of crystal growth to be determined.

The procedure adopted to test stability involved melting the glasses in 500- to 600-g melts and attempting to cool these melts as homogeneous glass blocks 3 in. in length by 3 in. in width by $\frac{1}{2}$ to $\frac{5}{8}$ in. in depth. Only compositions in which no devitrification occurred during cooling were considered to be glass forming. Only those compositions that melted below 1,500° C were studied. To insure uniformity the melts were stirred with rotating double-bladed platinum-10-percent-rhodium stirrers for 2 hr before being cast into the blocks. The glass-forming area thus defined was plotted on a composition diagram for interpretation.

In determining the liquidus temperature of various compositions a special holder, originally developed at the Bureau, was used.[2] This apparatus consists of an inverted platinum-10-percent-rhodium trough $5\frac{1}{2}$ in. long by $\frac{1}{2}$ in. wide. Small open cells tapering from a 2-mm diameter top to a 1-mm diameter bottom are spaced along the length of this holder. Crushed glass in pieces about 2 mm long and 1 mm wide is loaded into these holes, and the holder is positioned in a furnace with a known temperature gradient. Since the distance between holes and the temperature gradient are known, the temperature at each hole can be determined. The temperature at the hottest cell containing crystals is the liquidus temperature. Microscopic observations permit measurement of crystal sizes after various heat treatments, yielding data on rate of crystal growth.

A comparison of the experimental data with phase diagrams shows that compositions least likely to crystallize lie on flat liquidus surfaces or curves. The flat liquidus surface indicates the presence of a compound with a high degree of dissociation. The areas of relatively stable glasses may extend somewhat beyond the primary field of the dissociated compound. These adjacent areas may have relatively steep liquidus surfaces.

Just as stable glasses form from compositions on flat surfaces, compositions on steep surfaces, and not near a flat primary field, crystallize readily. In these

crystallizing compositions the melt becomes supersaturated with respect to the primary phase when cooled. The observed ease and high rate of crystallization suggest that there are already present in these melts the same structural units that later form as crystals. Conversely, in the flat liquidus fields crystallization is difficult because the highly dissociated compounds would have to reassociate before they could form crystals. On this basis it seems probable that multicomponent glasses are essentially solutions of chemical entities in dissociated chemical entities. This hypothesis does not necessarily contradict the random network theory often postulated to explain glass structure because the entities—both associated and dissociated—could still be randomly linked together in such a network.

The shape of the liquids surface as a criterion of stable glass formation, by Edgar H. Hamilton and Given W. Cleek, J. Research NBS **60**, 593 (1958) RP2872.

[2] An improved apparatus for the determination of liquidus temperatures and rates of crystal growth in glasses, by O. H. Grauer and Edgar H. Hamilton, J. Research NBS **44**, 495 (1950) RP2096; New method studies crystallization in glasses, NBS Tech. News Bul. **34**, 78 (June 1950).

Typical composition diagram of the barium titanium silicate system. $BaO \cdot TiO_2 \cdot 2SiO_2$ (10) is a highly dissociated compound at or above the liquidus temperature. The glass-forming compositions which lie between this compound and $BaO \cdot 3TiO_2$ (8) are considered to be composed of chemical entities of the composition $BaO \cdot 3TiO_2$ dissolved in the highly dissociated $BaO \cdot TiO_2 \cdot 2SiO_2$. The other glasses are similarly considered to be a solution of chemical entities (such as 2 and 3) in the highly dissociated chemical entity (10).
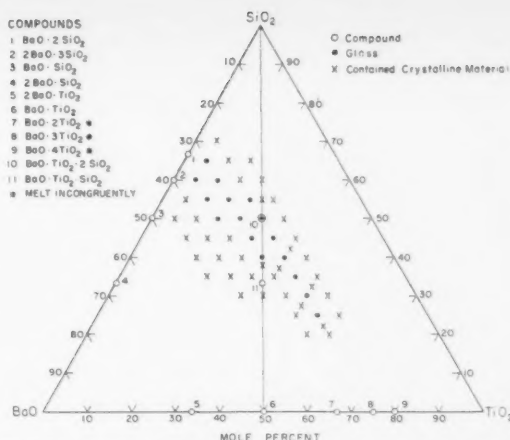
A 96-Point Aircraft Temperature Recorder

AS part of a program for the development of instruments for aeronautical research, the Bureau has designed and constructed for the Navy Bureau of Aeronautics, a compact device for the rapid and continuous recording of the readings of as many as 96 thermocouples. The instrument could be used, for example, in studying the temperature distribution, and its variation with time, over the "skin" of an aircraft. Development of the temperature recorder is due to A. B. Castle, Sr. of the mechanical instruments section.

When the recorder switch is set for automatic operation, a timer causes 8 of the thermocouple terminals to be connected to calibrated meters every $\frac{1}{2}$ sec; the illuminated dials of the meters and a frame counter are then photographed on a single frame of 16-mm movie film. All 96 readings are thus recorded in 6 sec. This cycle is repeated continuously for 15 min—that is, until the camera must be reloaded with film.

By suitably interconnecting the terminals to which the thermocouples are connected, one can use the instrument to record less than 96 thermocouples, with a consequent shortening of the time needed for a cycle of readings. For example, if only 48 thermocouples are used, the cycle is only 3 sec long; or, if only 8 thermocouples are connected to the instrument, their readings can be recorded every $\frac{1}{2}$ sec. In addition, there are auxiliary switches for manually stepping from one thermocouple to another or for single frame-taking.

Enlargement of a single frame of the 16-mm film made with the 96-point temperature recorder. The 8 readings (2 on each dial) show the temperature as measured by thermocouples distributed at various points in an aircraft.

The main components of the temperature recorder are an electromechanical timer, a selector switch, 4 double electrical meters (each with 2 dials and pointers), a modified 16-mm movie camera, and the terminal posts on the outside of the instrument for connection to the thermocouples. A $20 \times 10 \times 10$-in. aluminum box houses all components. To obtain sufficient distance between camera and dials, the camera is located behind an opening in the dial panel (which separates the box into 2 parts) and photographs the dials by way of a mirror on the inside of the facing end wall.

A special feature of the instrument is the modified version of a commercially available 16-mm movie camera. The modification provides an electrical drive, eliminating the need for manual winding, and permits both continuous and single-frame operation with automatic remote control. To achieve this result, the main

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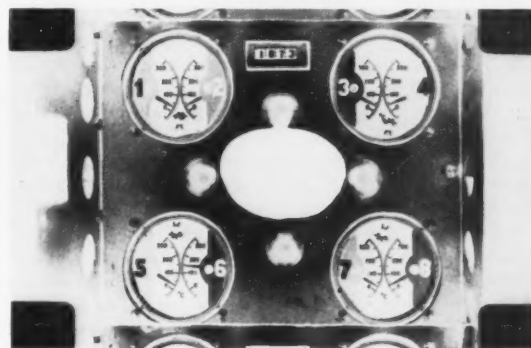
Ninety-six-point temperature recorder, developed for use in temperature studies on aircraft. A reel of film is shown being loaded into the modified 16-mm movie camera; the unit consisting of camera and frame counter (above) is then lowered into the opening in the box just below the camera.

operating spring and associated parts were replaced by a rotary solenoid, coil spring, and escapement mechanism. To prevent voltage variations from affecting film and shutter speed, and to limit the maximum force applied, the spring supplies the force for operation and the solenoid serves merely to extend the spring on each cycle. Camera speed is regulated by adjusting the spring tension. The greater flexibility and convenience of operation of the modified camera indicate that it could also be used to advantage in other recording applications besides the present one.

43d National Conference on Weights and Measures

A RESOLUTION adopted unanimously by the 43d National Conference on Weights and Measures indicated the strong feeling of State and local enforcement officials on the desirability of standard sizes for packaged commodities. Meeting in Washington, D. C. (June 9 to 13) under the sponsorship of the National Bureau of Standards, the conference devoted an entire session to technical papers and discussions on the subject of packages and labeling. The resolution took note of the fact that the average consumer is unable to compare values of competitive products with regard to quantity because of the great many odd sizes of packages, even including odd fractions of standard measurement units.

Secretary of Commerce Sinclair Weeks was the principal speaker at the Conference. At the first formal session, Secretary Weeks cited the National Conference on Weights and Measures as an excellent example of cooperation between the Federal Government and State and local governments. He emphasized that an effective weights and measures program provides a sound measurement foundation which helps all business, large and small, buyer and seller.

Other speakers at this session were A. V. Astin, Director of the National Bureau of Standards and President of the Conference. W. Muhe, of the Physikalisch-Technische Bundesanstalt, Braunschweig, Germany, and J. P. McBride, Director of Standards, State of Massachusetts and Chairman of the Conference. Honor award certificates were presented at this session to 2 delegates who had attended 20 conferences, 2 who had attended 15 conferences, and 12 who had attended 10 conferences. The balance of the program was devoted to the presentation of technical papers and committee reports and general discussion. Total registration was 424, with 39 states, the District of Columbia, Hawaii, and Puerto Rico represented.

The conference, which was organized in 1905, serves as a clearing house for weights and measures informa-

tion, and brings together weights and measures officials, as well as representatives of business and industry. Model laws, specifications, tolerances, regulations, and enforcement practices are recommended by the Conference for adoption by the various States, which have the legal responsibility of regulating commercial weighing and measuring devices, and of controlling commercial transactions involving quantity. The National Bureau of Standards, through its Office of Weights and Measures, cooperates with the States in this endeavor by providing reference standards, calibration service, and a wide range of technical advisory programs. Thus, the national standards of length and mass, which are in the custody of the Bureau, are translated into everyday use.

The conference, after amendments from the floor, adopted a report of the Committee on Laws and Regulations which dealt with several topics. It was recommended that Section 27 of the Model State Law on Weights and Measures be amended to read as follows: "That fluid milk, sweet and sour cream, and buttermilk in package form shall be packaged only in units of 1 gill, $\frac{1}{2}$ pint, 1 pint, 1 quart, $\frac{1}{2}$ gallon, 1 gallon, or multiples of 1 gallon, liquid measure: Provided that packages in units of less than 1 gill shall be permitted." The conference also recommended an amendment to Section 26 of the Model Law to read as follows: "That butter, oleomargarine, and margarine shall be offered and exposed for sale and sold by weight only in units of $\frac{1}{4}$ pound, $\frac{1}{2}$ pound, 1 pound, or multiples of 1 pound, avoirdupois weight."

The conference adopted the report of the Committee on Education, endorsing the consumer education plan presented by I. M. Levy, of Chicago, Ill., known locally as the "Betty Budget Series". It was recommended that weights and measures officials avail themselves of the offer of the City of Chicago to provide, at cost, appropriate newspaper mats for the series.

The Executive Committee recommended establish-

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n ent of a special committee to study the packaged flour situation, after an extensive discussion during its open meeting on the subject. Acting on the recommendation of the Committee on Specifications and Tolerances, the Conference adopted an amendment to the General Code, National Bureau of Standards Handbook 44, dealing with the indicators of commercial weighing and measuring equipment.

Officers of the Conference for the ensuing year include A. V. Astin, *ex officio* President, W. S. Bussey (Chief, NBS Office of Weights and Measures), *ex officio* Secretary, and the following who were elected: Chairman, C. M. Fuller (Los Angeles County, Calif.);

Vice Chairmen, H. C. Hulshoff (Niagara County, N. Y.), C. H. Stender (South Carolina), H. M. Turrell (Pennsylvania), E. C. Westwood (Salt Lake City, Utah); Treasurer, C. C. Morgan, (Gary, Ind.); Chaplain, J. H. Meek (Virginia). The elected officers will serve from the adjournment of the present meeting through the succeeding meeting which will be held June 8 to 12, 1959, in Washington.

NOTE: *The complete proceedings of the Conference are being published and are expected to be available within a few months. Meanwhile, multilithed copies of the Summary Report of the proceedings of the Conference are available without cost from the Office of Weights and Measures, National Bureau of Standards, on request.*

Publications of the National Bureau of Standards

Periodicals

Journal of Research of the National Bureau of Standards, Volume **61**, No. 1, July 1958 (RP2877 to RP2885 incl.). 60 cents. Annual subscription $4.00, $1.25 additional for foreign mailing.

Technical News Bulletin, Volume **42**, No. 7, July 1958. 10 cents.

Basic Radio Propagation Predictions for October 1958. Three months in advance. CRPL-D167. Issued July 1958. 10 cents. Annual subscription $1.00, 25 cents additional for foreign mailing.

Research Papers

Journal of Research, Volume 61, No. 1, July 1958. 60 cents.

RP2877. The system lime-alumina-water at 1° C. Elmer T. Carlson.

RP2878. Heat content of zirconium and of five compositions of zirconium hydride from 0° to 900° C. Thomas B. Douglas and Andrew C. Victor.

RP2879. Uniform transient error. Edith L. R. Corliss.

RP2880. Optical T-bench method of measuring longitudinal spherical aberration. Francis E. Washer.

RP2881. Mass spectrometric study of the rate of thermal decomposition of hydrazoic acid. J. L. Franklin, Vernon H. Dibeler, and Preston P. Morris, Jr.

RP2882. Erosion damage to solids caused by high-speed collision with rain. Olive G. Engel.

RP2883. Emission spectrum of carbon monoxide from 2.3 to 2.5 microns. Earle K. Plyler, Harry C. Allen, Jr., and Eugene D. Tidwell.

RP2884. Further studies of the influence of a ridge on the low-frequency ground wave. James R. Wait and Anabeth Murphy.

RP2885. Infrared studies of polymorphs of silicon dioxide and germanium dioxide. Ellis R. Lippincott, Alvin Van Valkenburg, Charles E. Weir, and Elmer N. Bunting.

Circulars

C593. The Federal basis for weights and measures. Ralph W. Smith. 30 cents.

Applied Mathematics Series

AMS53. Table of natural logarithms for arguments between five and ten to sixteen decimal places. $4.00.

Handbooks

H66. Safe design and use of industrial beta-ray sources. 20 cents.

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Reversible contractile processes in fibrous macromolecules. L. Mandelkern, D. E. Roberts, and A. F. Diorio, J. Am. Chem. Soc. **80**, 500 (1958).

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Simplified approach to spin in dirac theory. H. Mendlowitz. Am. J. Phys. **26**, No. 1, 17–24 (Jan. 1958).

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Amplitude stabilization of a microwave signal source. G. F. Engen. IRE Trans. on Microwave Theory and Tech. **MTT–6**, No. 2, 202 (Apr. 1958).

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The addition of hydrogen atoms to solid olefins at −195°. Ralph Klein and Milton D. Scheer. J. Am. Chem. Soc. **80**, 1007 (1958).

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TECHNICAL NEWS BULLETIN

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NBS Publications (*Continued*)

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Automation in the laboratory. Bourdon F. Scribner. Capital Chem. **8**, 38 (Jan. 1958).

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Emission spectroscopy. Bourdon F. Scribner. Anal. Chem. **30**, No. 4, 596 (Apr. 1958).

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Physical properties of chromium-cobalt dental alloys. Daune F. Taylor, Walter A. Leibfritz, and Alfred G. Adler. J. Am. Dental Assoc. **56**, 343 (Mar. 1958).

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